Laboratoire d'accueil

Intitulé : UMR Marbec (Marine Biodiversity Exploitation Conservation) http://www.umr-marbec.fr/fr/
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Title: Conservation of Vulnerable Marine Ecosystems (VME) in the Mediterranean Sea: indicator species distribution models and assessment of fishery risk of impact

Aims of this work:

1) To produce present habitat suitability maps of the VMEs at Mediterranean scale and identify future climate refugia
2) To assess the risk of potential impact of fishery activities on VME to support biodiversity conservation

Objectives:

1) Applying an ensemble of models to study the relationship between species presence/absence and environmental conditions at large scale.
2) Investigate the effect of local environmental variables on species yields or density at sub-regional scale.
3) Use models to identify climate refugia in the face of expected climate change
4) Evaluate the risk of encounter with bottom-impacting fisheries at both scales through cross-mapping of predicted VMEs and activity maps.

Expected skills that will be developed during the project:

Ecologie marine, Concepts en écologie marine (approche écosystémique, gestion spatialisée)

Ecologie numérique: Bonne maîtrise de R, techniques d'analyses statistiques et manipulation de données spatialisée sous R

Rigueur et méthode, sens de l'organisation, qualités rédactionnelles

Esprit d'initiative et d'ouverture, travail collaboratif

Bonne maitrise de l'anglais (pour interaction forte avec la seconde encadrante)

Background

VME indicator species play a significant structural role in marine benthic ecosystems either by providing essential three-dimensional habitats for fish and invertebrate communities, acting as biodiversity hot spots and contributing to the maintenance of ecosystem functioning. Their life history traits make them highly vulnerable to human-induced impacts (e.g. fishing, pollution, coastal development, invasive species, and climate change). Consequently, a lack of management

to preserve these species may have permanent or irreversible effects on the entire marine ecosystem. Fisheries, in particular bottom trawling, have dramatic impacts on benthic communities as they remove most of the habitat forming organisms from the seafloor and alter its morphology and physical proprieties. The impact of fisheries has been increasing over the last decades in response to the decline of many shelf commercial stocks. As a result the abundance of VME indicators have been diminishing and their recovery could take decades or centuries. Although international policies (GFCM, EU MFSD) recognized the fragility of these habitats, most of them still lack a comprehensive ecological characterisation, including spatial distribution maps.

Due to such threats adequate marine spatial planning is essential for the conservation of these important habitats in the Mediterranean Sea. Species distribution models (SDMs) have been increasingly used amongst conservation biologists, ecologists and government bodies to identify where VMEs could occur at regional and global scales and to provide insight into the environmental drivers that control their distribution (Lauria et al., 2017, Morato et al., 2019). The main advantages of using such models is the ability to predict the species presence or abundance at unsurveyed locations, to understand species-environment relationships and to provide distribution maps that can be used to inform policy makers (e.g. planning of marine protected areas). In this study SDMs will be used to investigate species distribution, potential climate change and fisheries impacts on several such species. Predictive distribution maps will be produced in order to identify species-specific spatial patterns at a regional scale under present and future conditions, to provide new knowledge about the habitat preferences and fishing impact on the studied species and will support future spatial conservation plans for VMEs in the Mediterranean Sea.

Survey and environmental data

Survey data

Since 1994 the area has been investigated under the Mediterranean International Trawl Survey program -MEDITS [43]. This survey is carried out annually in late spring/early summer, and takes place in several areas of the Mediterranean Sea using a standardized sampling methodology. At each trawl station the collected species were sorted, weighed, counted. Species density and yield

are calculated as the number of individuals or kg per km^2. Survey data is already available over several areas in the western basin in a standardized format (covering the period 2008/2012-2019).

Species that may be studied:

Species	VME
Antedon	Mud and Sand emergent Fauna
Funiculina quadrangularis	Sea Pen fields
Isidella elongata	Soft-bottom coral gardens
Leptometra phalangium	Mud and Sand emergent Fauna
Pennatula phosphorea	Sea Pen fields
Pennatula rubra	Sea Pen fields
Pteroeides spinosum	Sea Pen fields

Environmental and fishery variables

For modelling, present and future environmental variables may be used as predictors of species habitat suitability. Environmental variables may include physical descriptors (i.e. depth, slope, rugosity, aspect) and oceanographic variables (i.e. sea bottom temperature - SBT, sea bottom salinity - SBS and currents). The latter extracted from biooracle (https://bio-oracle.org/) may be used to simulate climate change. Digital continuous maps will be produced for all the variables from existing open-access databases, or derived from GIS treatment of available data.

The fishing pressure exerted by trawlers in the area will be used to quantify the potential impact of towed fisheries. It may be estimated through the vessel monitoring system (VMS) to assess the spatial distribution of the fishing effort in terms of number of fishing hours per year. Alternatively, fishery induced abrasion (Jac et Vaz, 2018) or catches (Watson, 2019) may also be used depending on the scale investigated and data access and availability at that scale.

Methodology proposed

This project will use a multi-scale approach because of the natural environmental gradients in the Mediterranean Sea and the different fishing patterns across the basin (Hattab et al, 2014). The ecological processes responsible for presence of a species are believed to be large scale, close to the climate envelope of the species. Those responsible for its local biomass or density encompass both exogenous (local environmental constraints including human uses) and endogenous (local

population dynamics and plasticity). Therefore, they should be treated separately. Species presence/absence, densities or yield will be extracted from available datasets and modelled as a function of physical (e.g. depth, slope, rugosity, aspect, sediment grain size), oceanographic (e.g. sea bottom temperature, sea bottom salinity and currents). All possible models will be generated based on a calibration dataset and used to predict response based on independent data set (by cross-validation using EnMEVAL or SDMselect routines in R). Final models will be selected based on their predictive power. This will be applied to both basin and regional/local scale.

Basin scale approach: First presence/absence models (climate envelope) will be applied at largest available scale. An ensemble of models (such as MAXENT; GAMs; RANDOM FOREST, e.g. Morato et al 2019) will be used. This large scale models will predict present and possibly future habitat suitability in the form of probability of presence, HSI or presence/absence large scale predictions. These will be used to identify climate refugia for each studied species

Local/Regional scale approach: By using appropriate local descriptors the effect of local environment and fisheries on the spatial distribution of VME species indicators will be investigated. This approach will use simple GAMs (Gaussian or gamma error). The effect of local descriptors (currents, productivity) reflecting local constrain on growth and demographic characteristic will be tested at these variables may condition the abundance or biomass level observed.

This local model may be then weighted by the large-scale model to account for both large scale processes conditioning the presence of the species and local processes shaping the abundance of the population (present and future).

Risk evaluation: Present and future distribution of each and all species will be cross-mapped with fishery proxies (i.e. average distribution of the fishing effort or catches over time) to evaluate the overall risk induced to VME by present fishery activities.

References:

Hattab Tarek, Albouy Camille, Lasram Frida Ben Rais, Somot Samuel, Le Loc'h Francois, Leprieur Fabien (2014). Towards a better understanding of potential impacts of climate change on marine species distribution: a multi-scale modelling approach. Global Ecology And Biogeography , 23(12), 1417-1429 . https://doi.org/10.1111/geb.12217

Jac Cyrielle, Vaz Sandrine (2018). Abrasion superficielle des fonds par les arts trainants – Méditerranée (surface Swept Area Ratio). IFREMER. https://doi.org/10.12770/8bed2328-a0fa-4386-8a3e-d6d146cafe54

Lauria, V., Garofalo, G., Fiorentino, F. et al. Species distribution models of two critically endangered deep-sea octocorals reveal fishing impacts on vulnerable marine ecosystems in central Mediterranean Sea. Sci Rep 7, 8049 (2017). https://doi.org/10.1038/s41598-017-08386-z

Morato et al. 2019. Climate-induced changes in the suitable habitat of cold-watercorals and commercially important deep-sea fishes in the North Atlantic. Global Change Biology. DOI: 10.1111/gcb.14996

Watson, R.A. (2019). Global Fisheries Landings V4.0. Institute for Marine and Antarctic Studies (IMAS), University of Tasmania (UTAS). doi:10.25959/5c522cadbea37